

US008873990B2

(12) **United States Patent**  
**Taishi et al.**

(10) **Patent No.:** **US 8,873,990 B2**  
(45) **Date of Patent:** **Oct. 28, 2014**

(54) **TONER DENSITY SENSOR AND IMAGE FORMING APPARATUS**

(71) Applicant: **OMRON Corporation**, Kyoto (JP)

(72) Inventors: **Yoshitaka Taishi**, Ritto (JP); **Hajime Kawai**, Kyoto (JP)

(73) Assignee: **OMRON Corporation**, Kyoto (JP)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 158 days.

(21) Appl. No.: **13/681,881**

(22) Filed: **Nov. 20, 2012**

(65) **Prior Publication Data**

US 2013/0243466 A1 Sep. 19, 2013

(30) **Foreign Application Priority Data**

Mar. 15, 2012 (JP) ..... 2012-059045

(51) **Int. Cl.**

**G03G 15/00** (2006.01)

**G03G 15/10** (2006.01)

**G03G 15/08** (2006.01)

(52) **U.S. Cl.**

CPC ..... **G03G 15/5025** (2013.01); **G03G 15/5054** (2013.01); **G03G 15/0862** (2013.01)

USPC ..... **399/74**; 399/64

(58) **Field of Classification Search**

USPC ..... 399/74, 64

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,655,936 B2 \* 2/2010 Sawayama et al. .... 250/559.4  
2004/0251435 A1 \* 12/2004 Sawayama et al. .... 250/559.16

FOREIGN PATENT DOCUMENTS

JP 2005-091252 A 4/2005

\* cited by examiner

*Primary Examiner* — Walter L Lindsay, Jr.

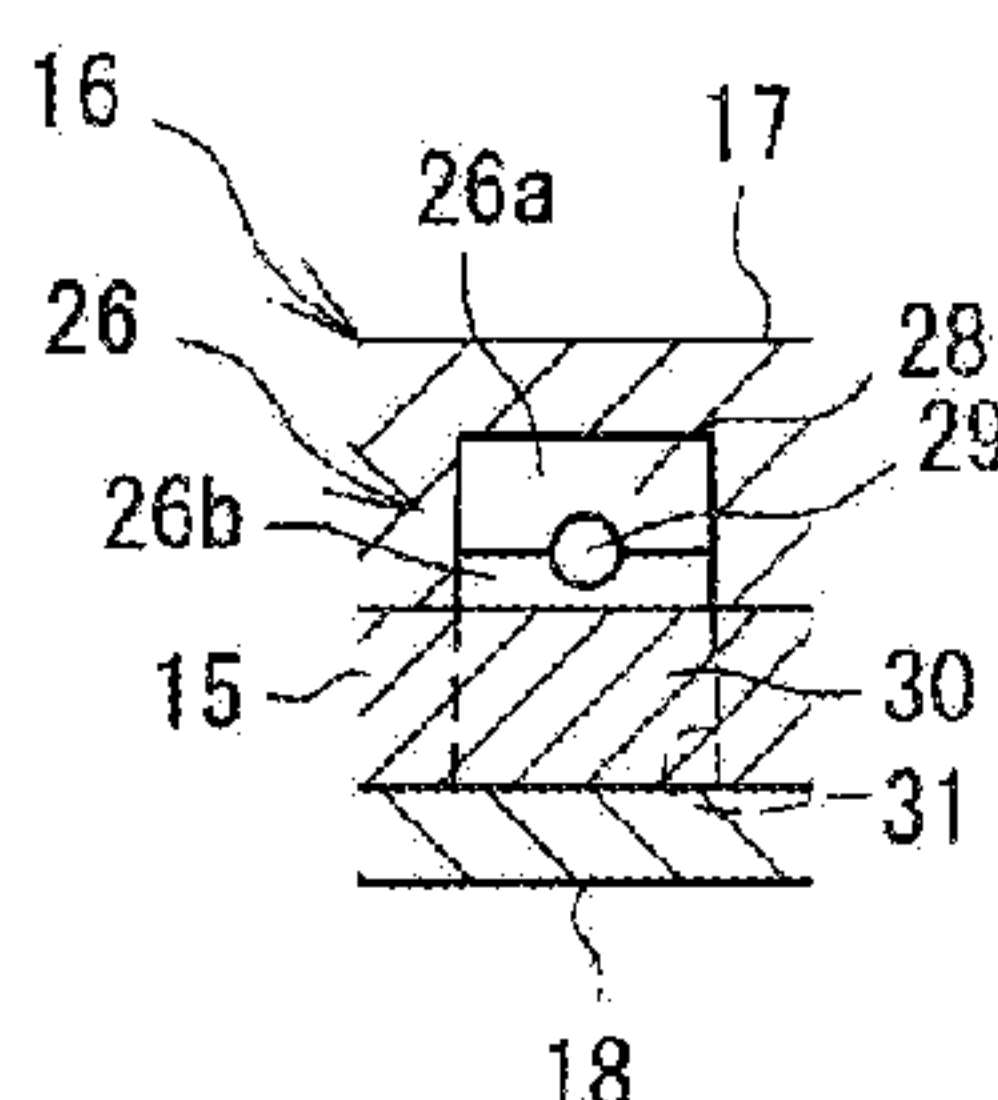
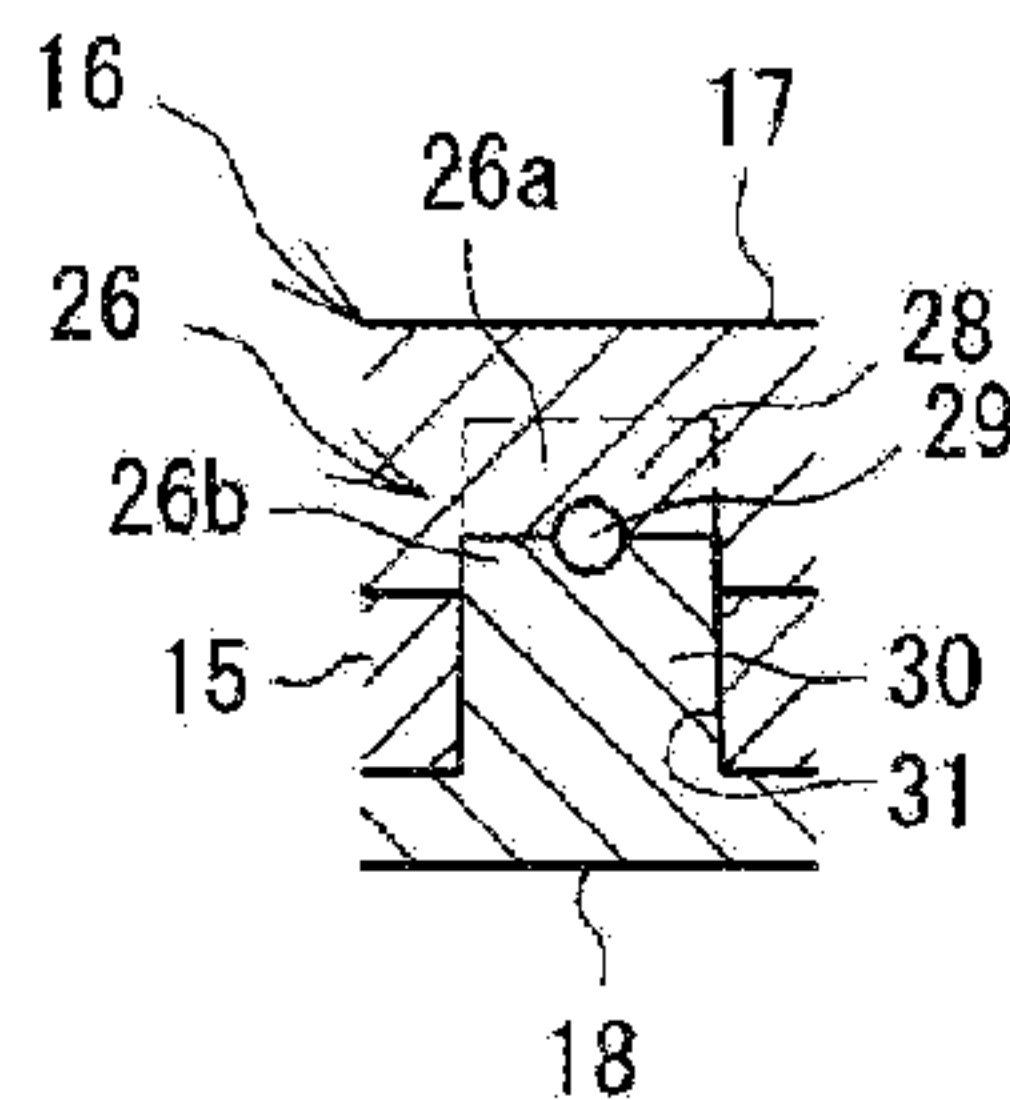
*Assistant Examiner* — Rodney Bonnette

(74) *Attorney, Agent, or Firm* — Nutter McClennen & Fish LLP; John J. Penny, Jr.

(57) **ABSTRACT**

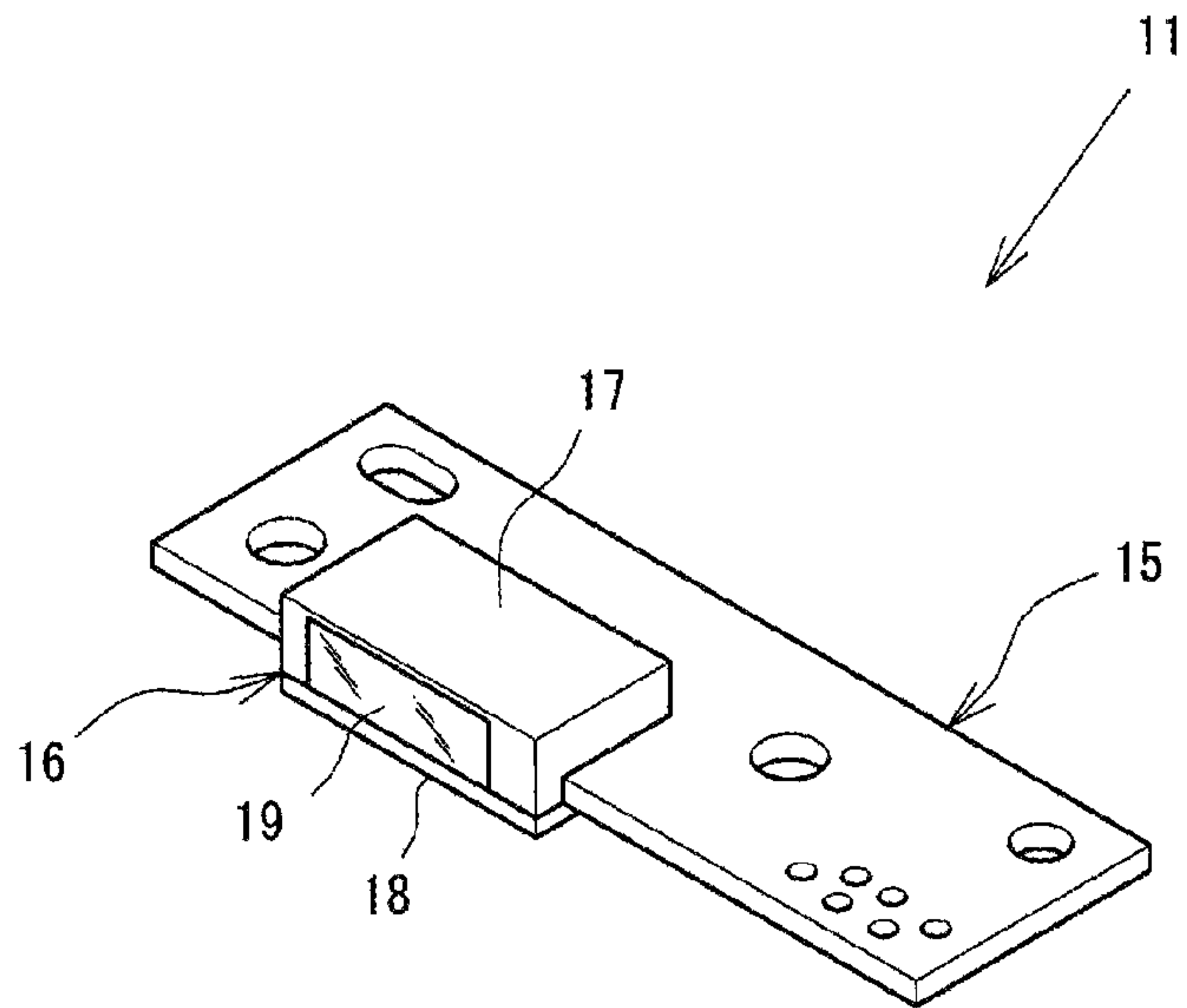
A toner density sensor comprising: a light emitting element that emits light; a light receiving element that receives reflected light emitted from the light emitting part and reflected at a detection target; a light path for passage of emitted and reflected light formed along the front surface of a printed substrate on which the light emitting element and the light receiving element are surface-mounted; and a diaphragm unit that is formed at and partially narrows this light path, wherein the diaphragm unit is divided into two portions, a diaphragm unit upper-portion and a diaphragm unit lower-portion, and these are disposed in an upper case covering the front surface of the printed substrate and in a lower case covering the rear surface of the printed substrate. In the printed substrate, a through hole is formed for protrusion of the diaphragm unit lower portion from the rear surface to the front surface.

**12 Claims, 9 Drawing Sheets**



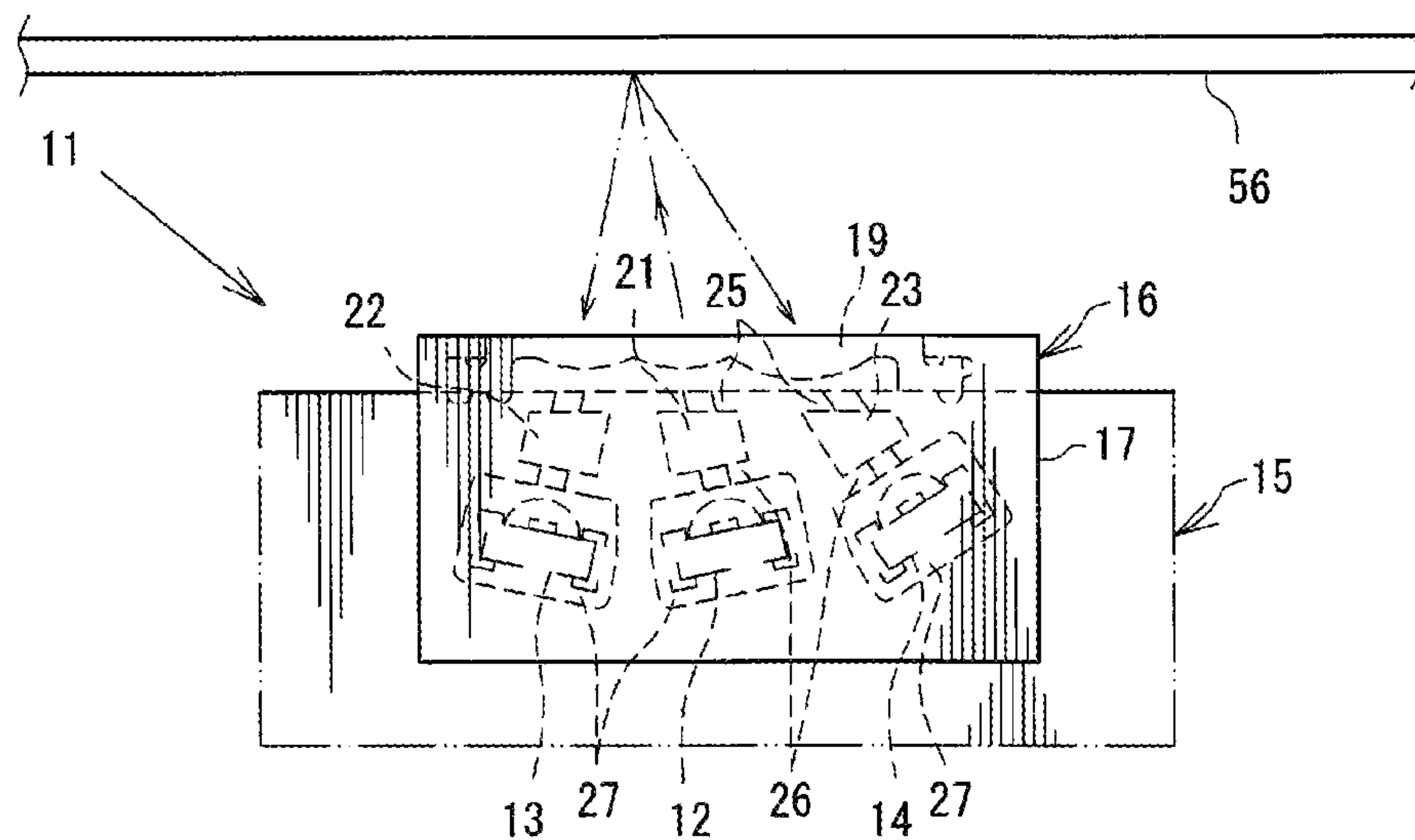
- 11 --- TONER DENSITY SENSOR
- 12 --- LIGHT EMITTING ELEMENT
- 13,14 --- LIGHT RECEIVING ELEMENT
- 15 --- PRINTED SUBSTRATE
- 17 --- UPPER CASE
- 18 --- LOWER CASE
- 21 --- IRRADIATION PATH
- 22, 23 --- LIGHT RECEIVING PATH
- 25, 26 --- DIAPHRAGM UNIT
- 25a, 26a --- UPPER-SIDE DIAPHRAGM UNIT
- 25b, 26b --- LOWER-SIDE DIAPHRAGM UNIT
- 30 --- PROTRUSION
- 31 --- THROUGH HOLE

FIG. 1



- 11 --- TONER DENSITY SENSOR
- 15 --- PRINTED SUBSTRATE
- 17 --- UPPER CASE
- 18 --- LOWER CASE

FIG. 2



- 11 --- TONER DENSITY SENSOR
- 12 --- LIGHT EMITTING ELEMENT
- 13, 14 --- LIGHT RECEIVING ELEMENT
- 15 --- PRINTED SUBSTRATE
- 17 --- UPPER CASE
- 21 --- IRRADIATION PATH
- 22, 23 --- LIGHT RECEIVING PATH
- 25, 26 --- DIAPHRAGM UNIT
- 56 --- TRANSFER BELT

FIG. 3

- 11 --- TONER DENSITY SENSOR
- 51 --- IMAGE FORMING APPARATUS
- 56 --- TRANSFER BELT

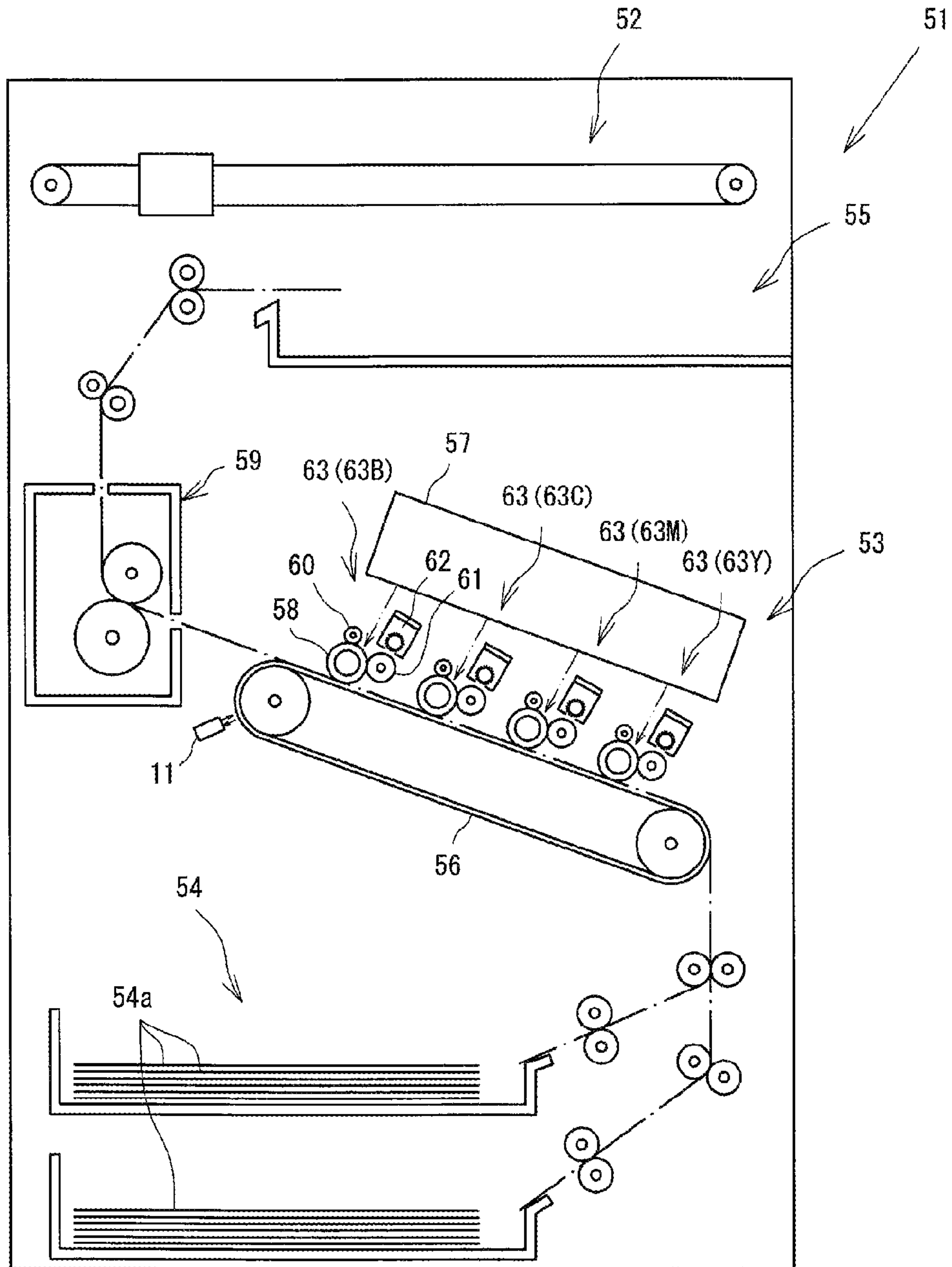




FIG. 4A

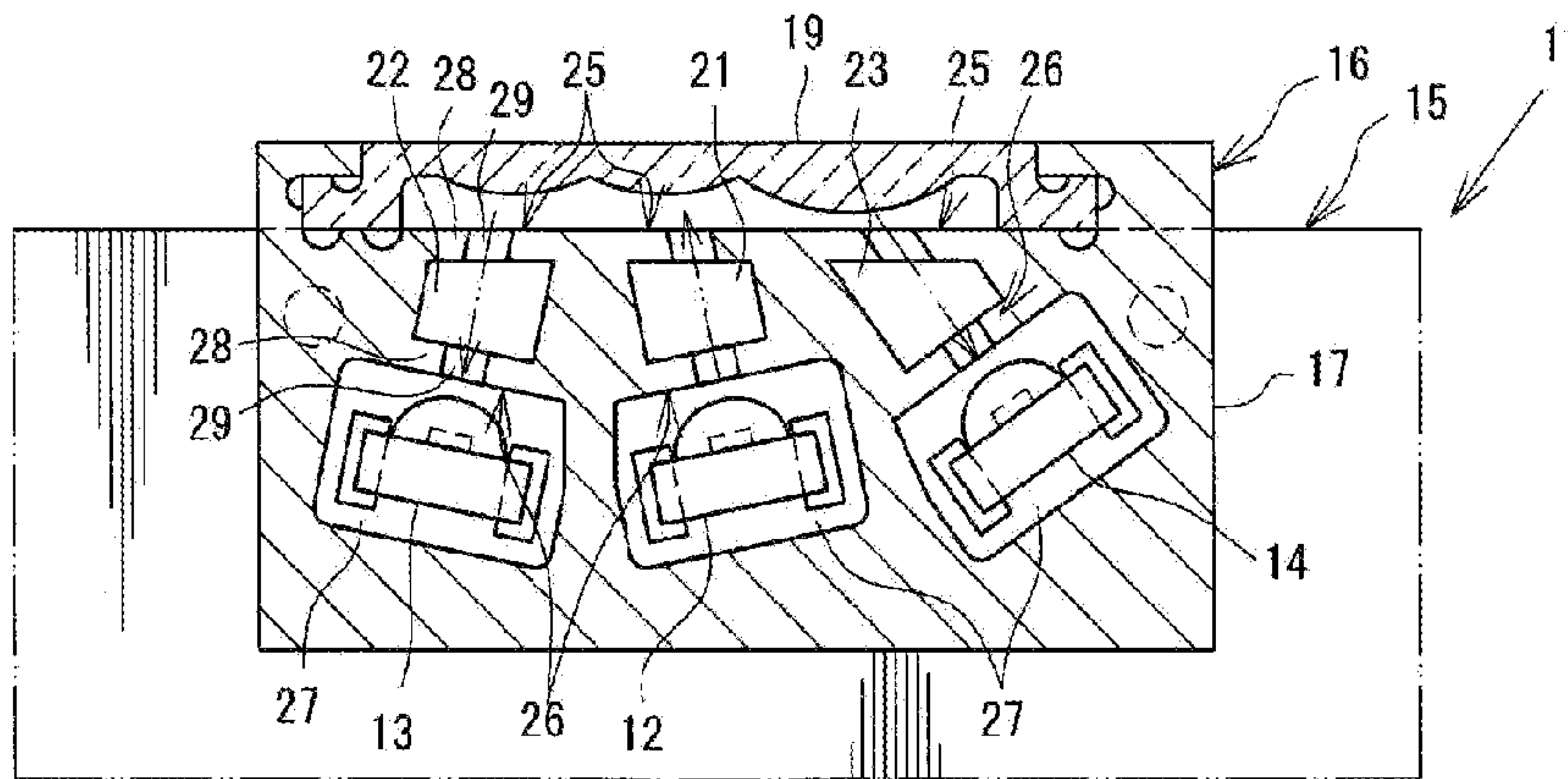
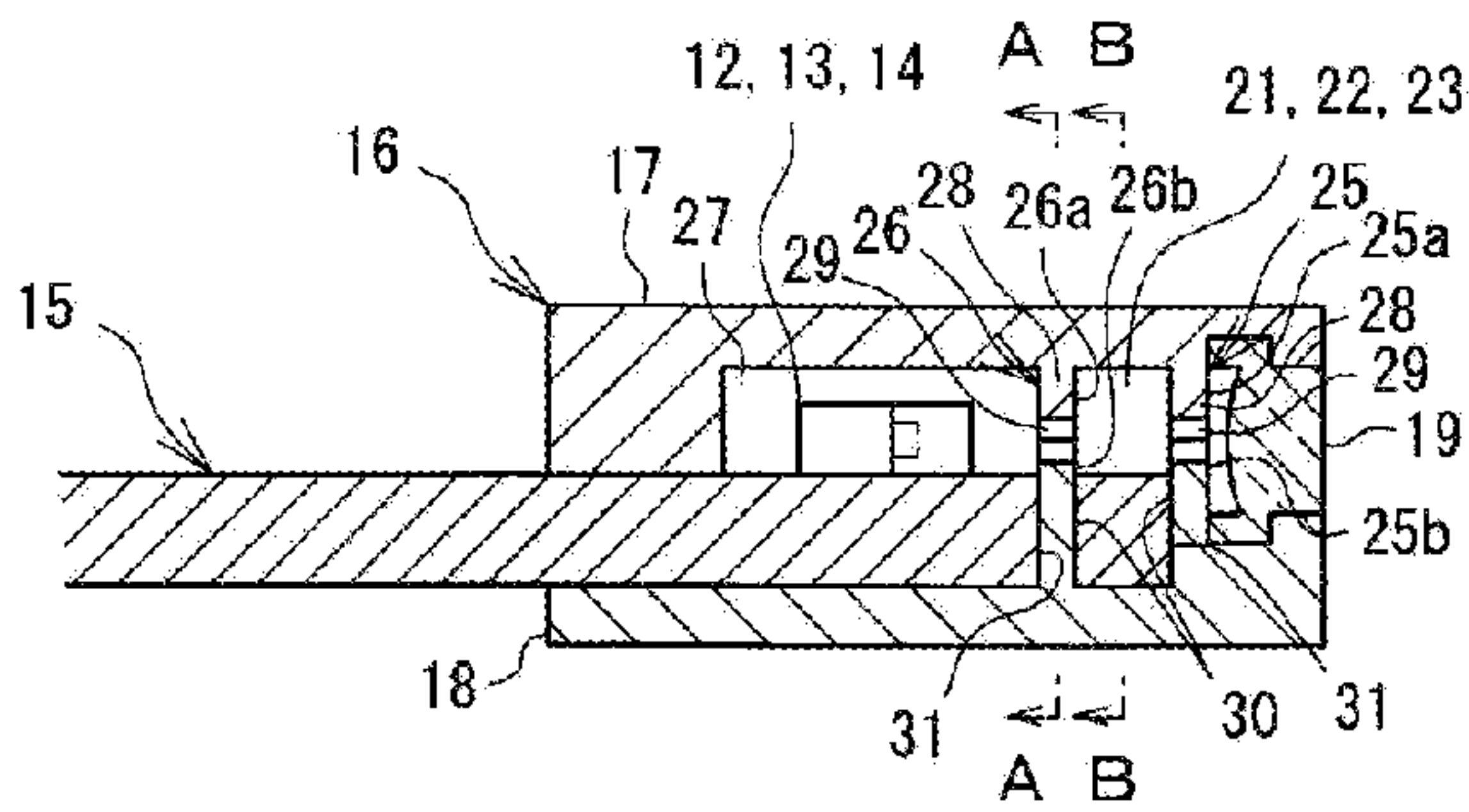


FIG. 4B



- 11 --- TONER DENSITY SENSOR
- 12 --- LIGHT EMITTING ELEMENT
- 13,14 --- LIGHT RECEIVING ELEMENT
- 15 --- PRINTED SUBSTRATE
- 17 --- UPPER CASE
- 18 --- LOWER CASE
- 21 --- IRRADIATION PATH
- 22, 23 --- LIGHT RECEIVING PATH
- 25, 26 --- DIAPHRAGM UNIT
- 25a, 26a --- UPPER-SIDE DIAPHRAGM UNIT
- 25b, 26b --- LOWER-SIDE DIAPHRAGM UNIT
- 30 --- PROTRUSION
- 31 --- THROUGH HOLE

FIG. 4C

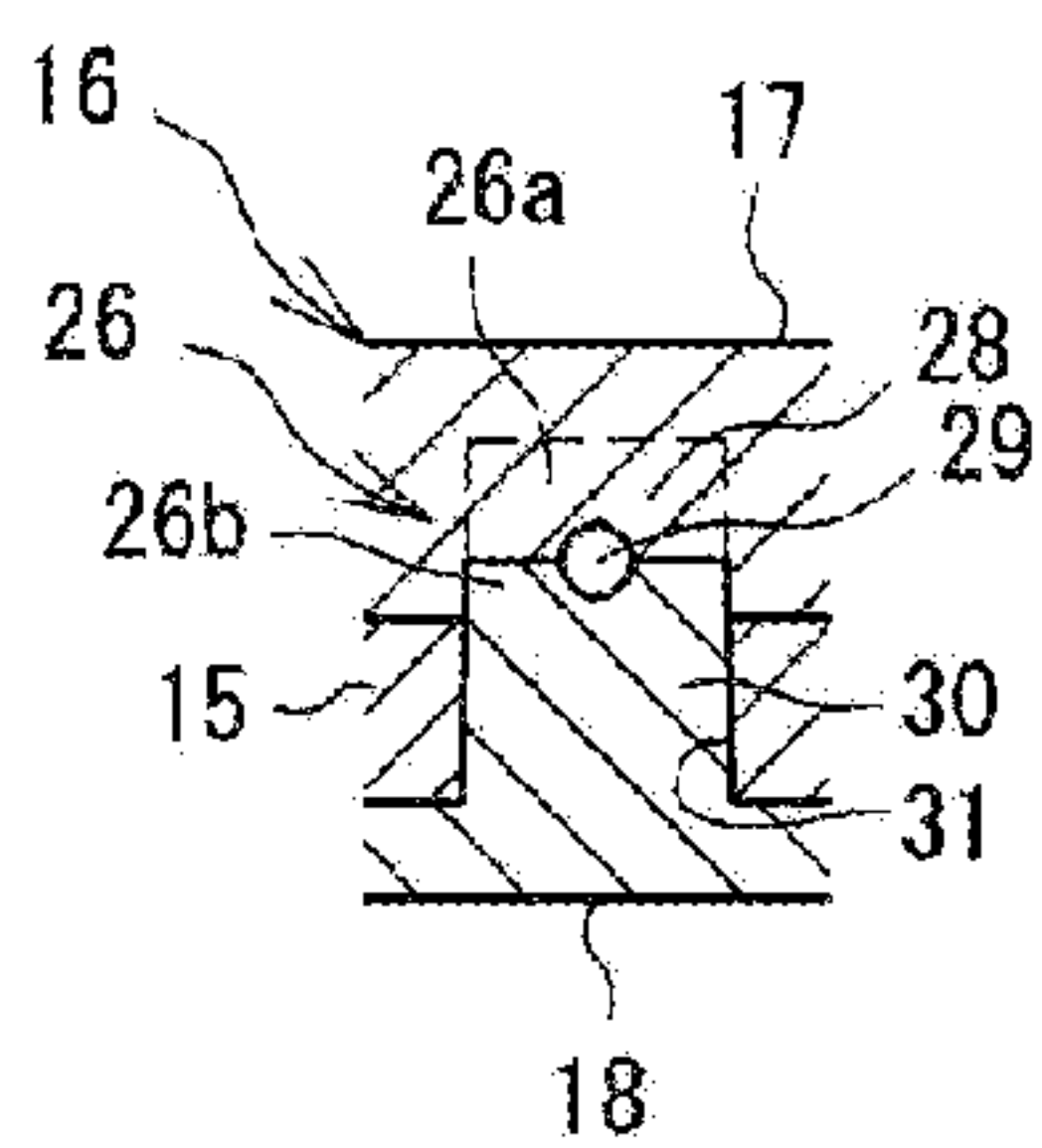


FIG. 4D

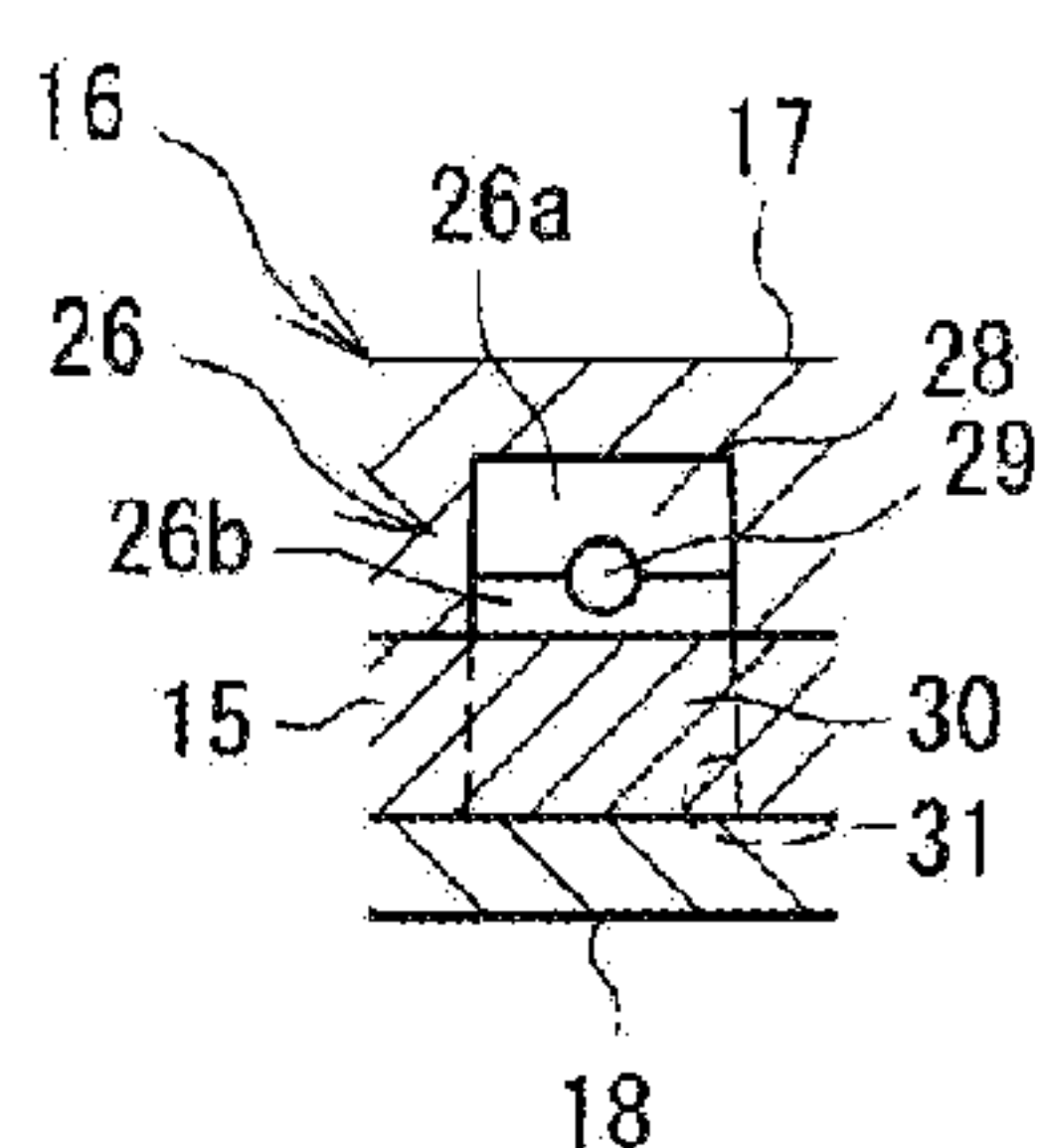
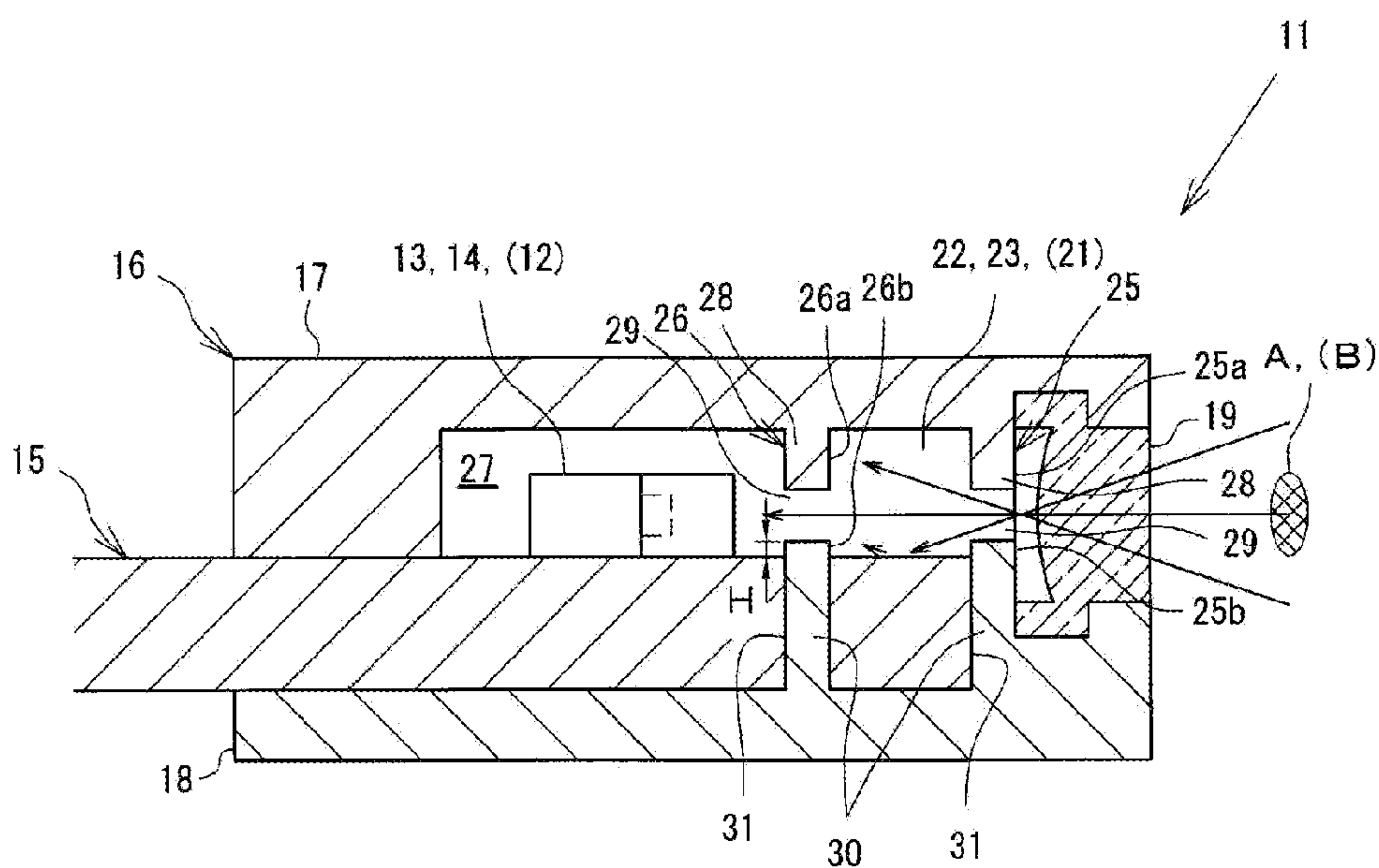


FIG. 5



11 --- TONER DENSITY SENSOR  
 12 --- LIGHT EMITTING ELEMENT  
 13, 14 --- LIGHT RECEIVING ELEMENT  
 15 --- PRINTED SUBSTRATE  
 17 --- UPPER CASE  
 18 --- LOWER CASE  
 21 --- IRRADIATION PATH

22, 23 --- LIGHT RECEIVING PATH  
 25, 26 --- DIAPHRAGM UNIT  
 25a, 26a --- UPPER-SIDE DIAPHRAGM UNIT  
 25b, 26b --- LOWER-SIDE DIAPHRAGM UNIT  
 30 --- PROTRUSION  
 31 --- THROUGH HOLE

FIG. 6A

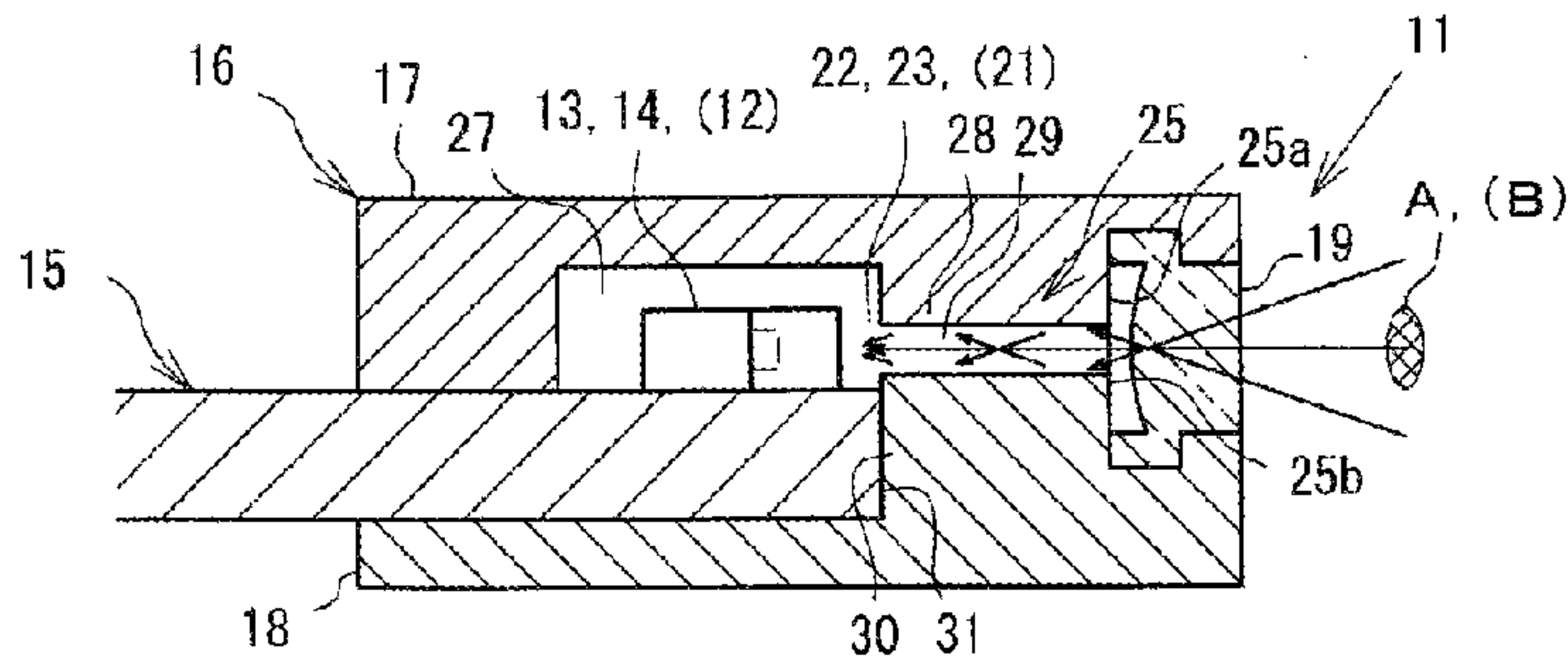


FIG. 6B

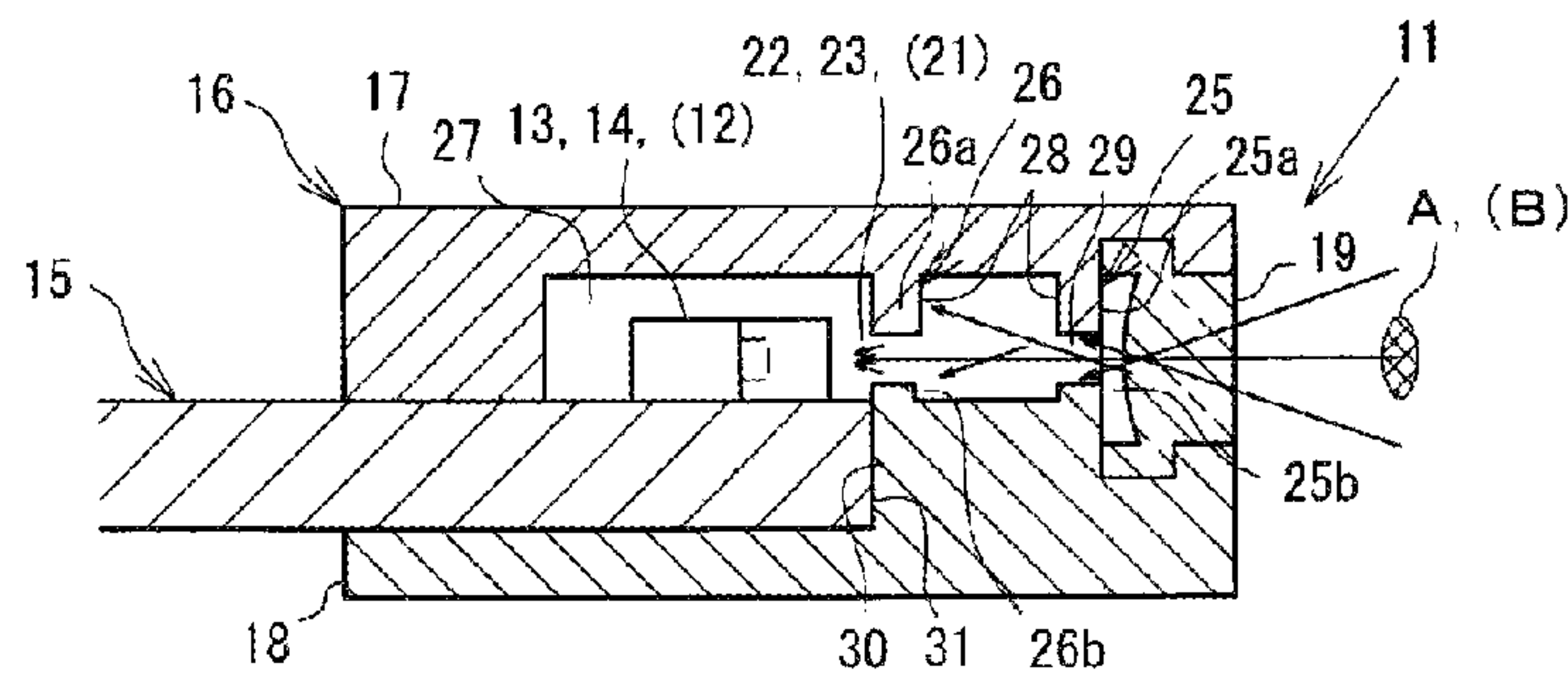


FIG. 6C

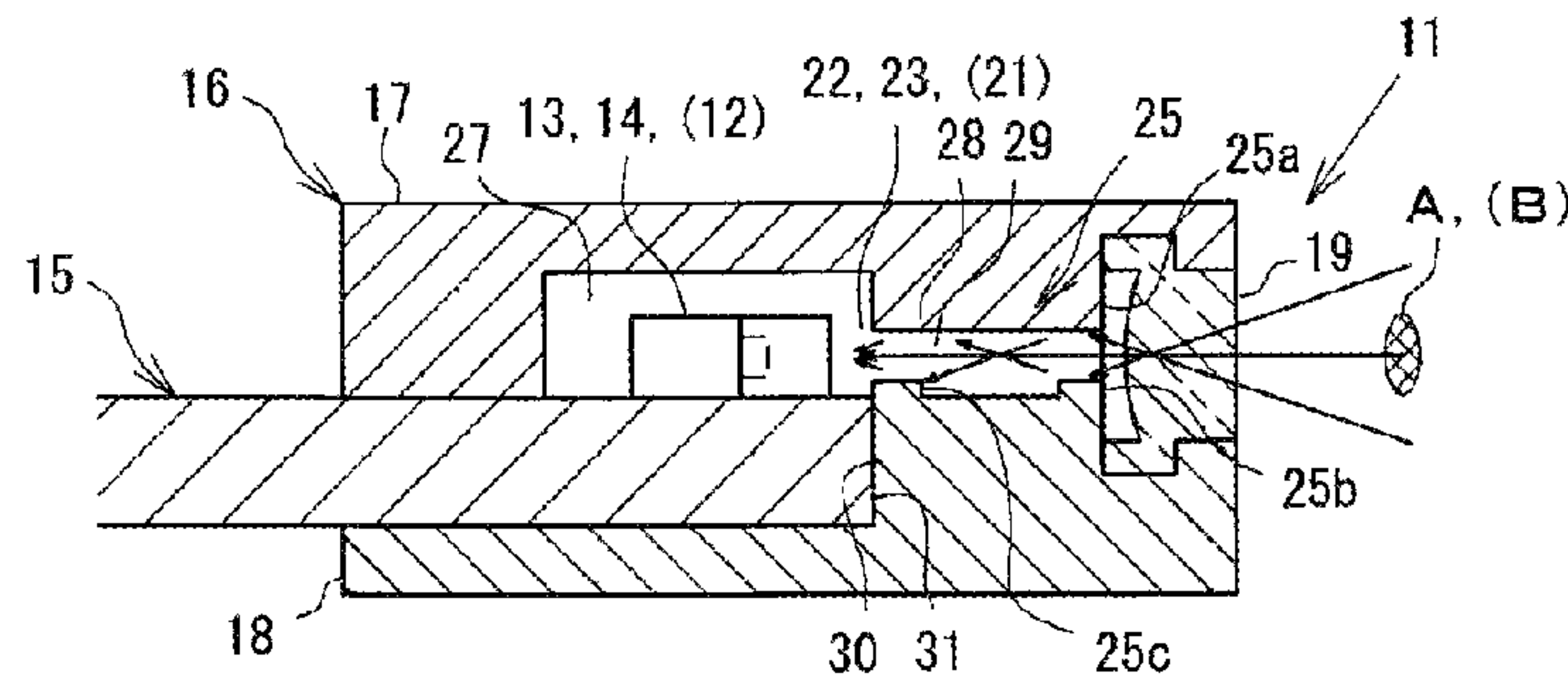
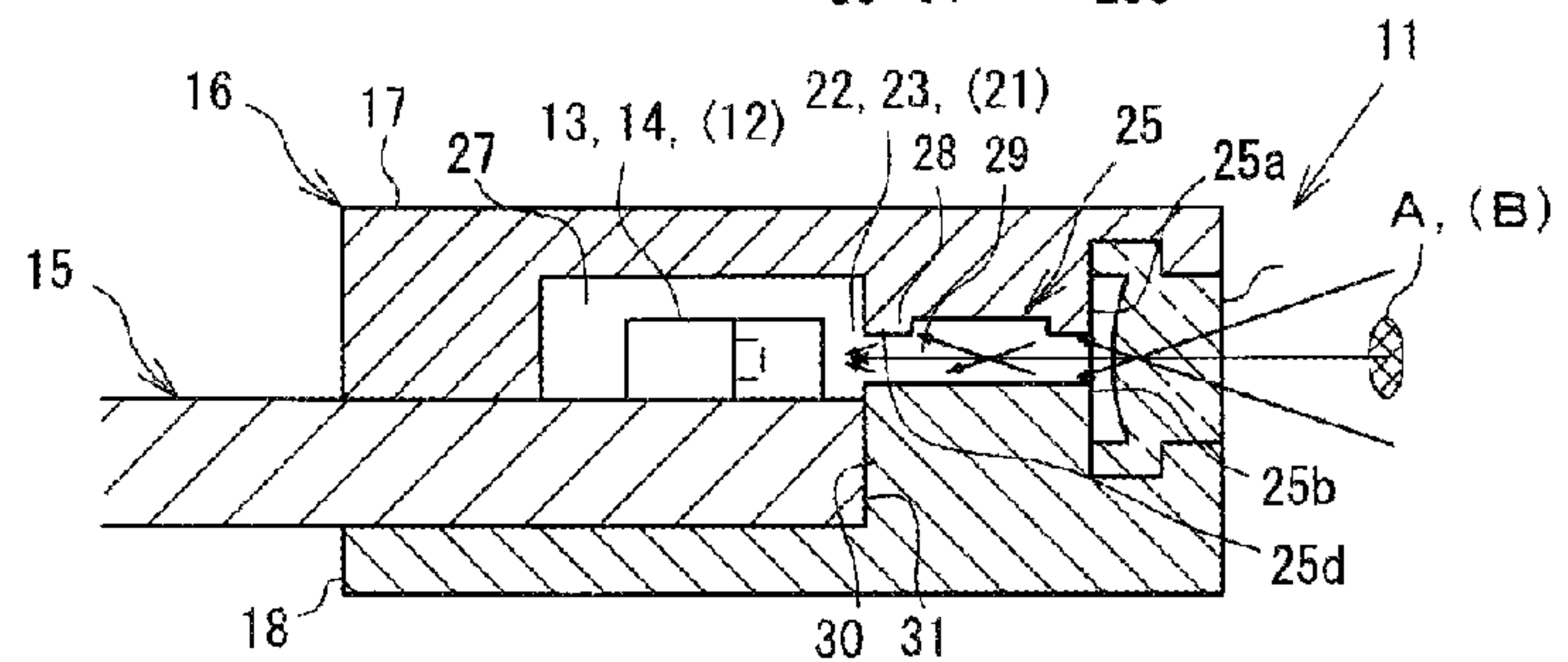
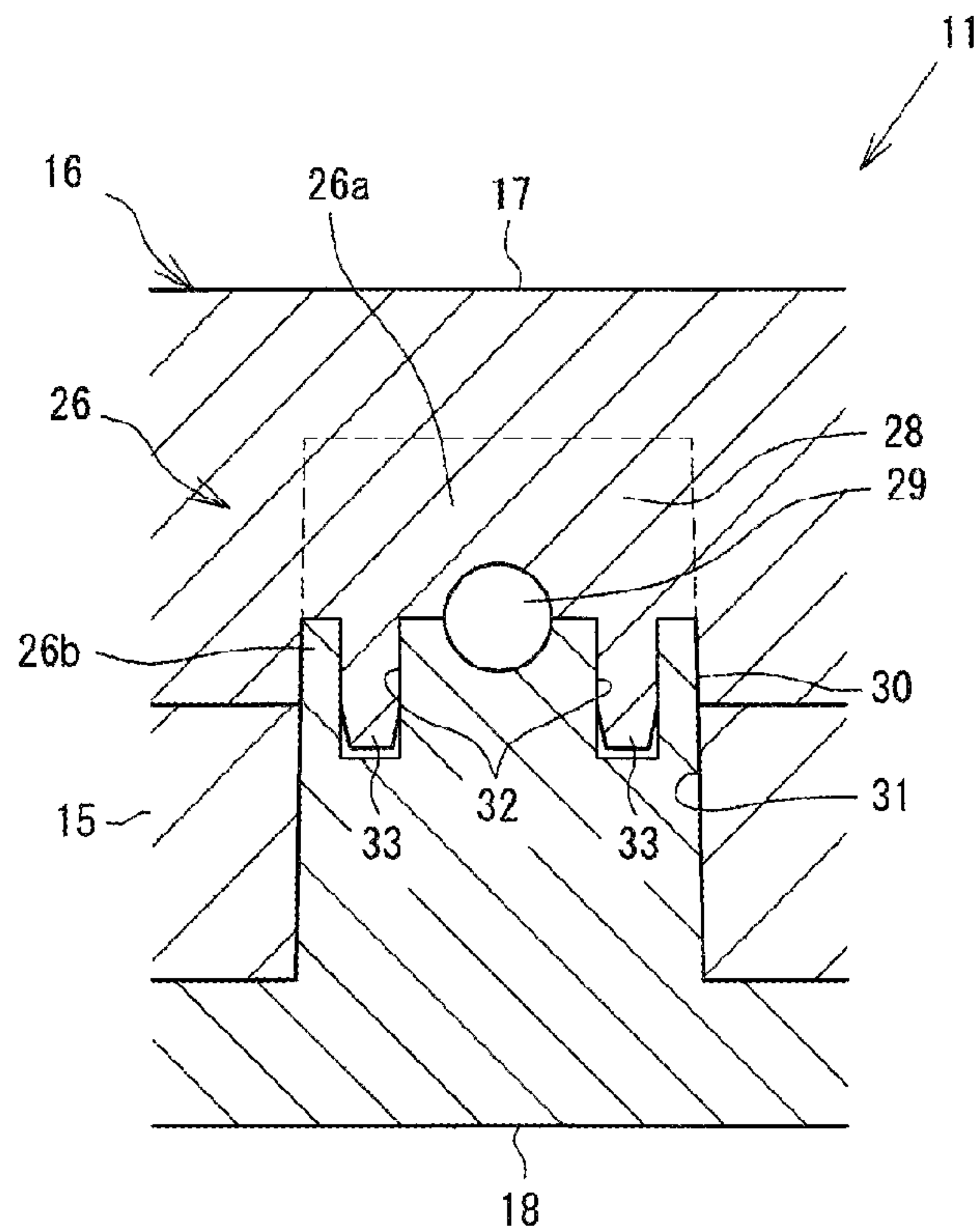


FIG. 6D



- |                                    |                                 |   |
|------------------------------------|---------------------------------|---|
| 11 --- TONER DENSITY SENSOR        | 17 --- UPPER CASE               | 25, 26 --- DIAPHRAGM UNIT                   |
| 12 --- LIGHT EMITTING ELEMENT      | 18 --- LOWER CASE               | 25a, 25d, 26a --- UPPER-SIDE DIAPHRAGM UNIT |
| 13, 14 --- LIGHT RECEIVING ELEMENT | 21 --- IRRADIATION PATH         | 25b, 25c, 26b --- LOWER-SIDE DIAPHRAGM UNIT |
| 15 --- PRINTED SUBSTRATE           | 22, 23 --- LIGHT RECEIVING PATH | 30 --- PROTRUSION                           |
|                                    |                                 | 31 --- THROUGH HOLE                         |

FIG. 7



11 --- TONER DENSITY SENSOR  
 15 --- PRINTED SUBSTRATE  
 17 --- UPPER CASE  
 18 --- LOWER CASE  
 26 --- DIAPHRAGM UNIT  
 26a --- UPPER-SIDE DIAPHRAGM UNIT

26b --- LOWER-SIDE DIAPHRAGM UNIT  
 30 --- PROTRUSION  
 31 --- THROUGH HOLE  
 32 --- FIT HOLE  
 33 --- FIT PROTRUSION



FIG. 8

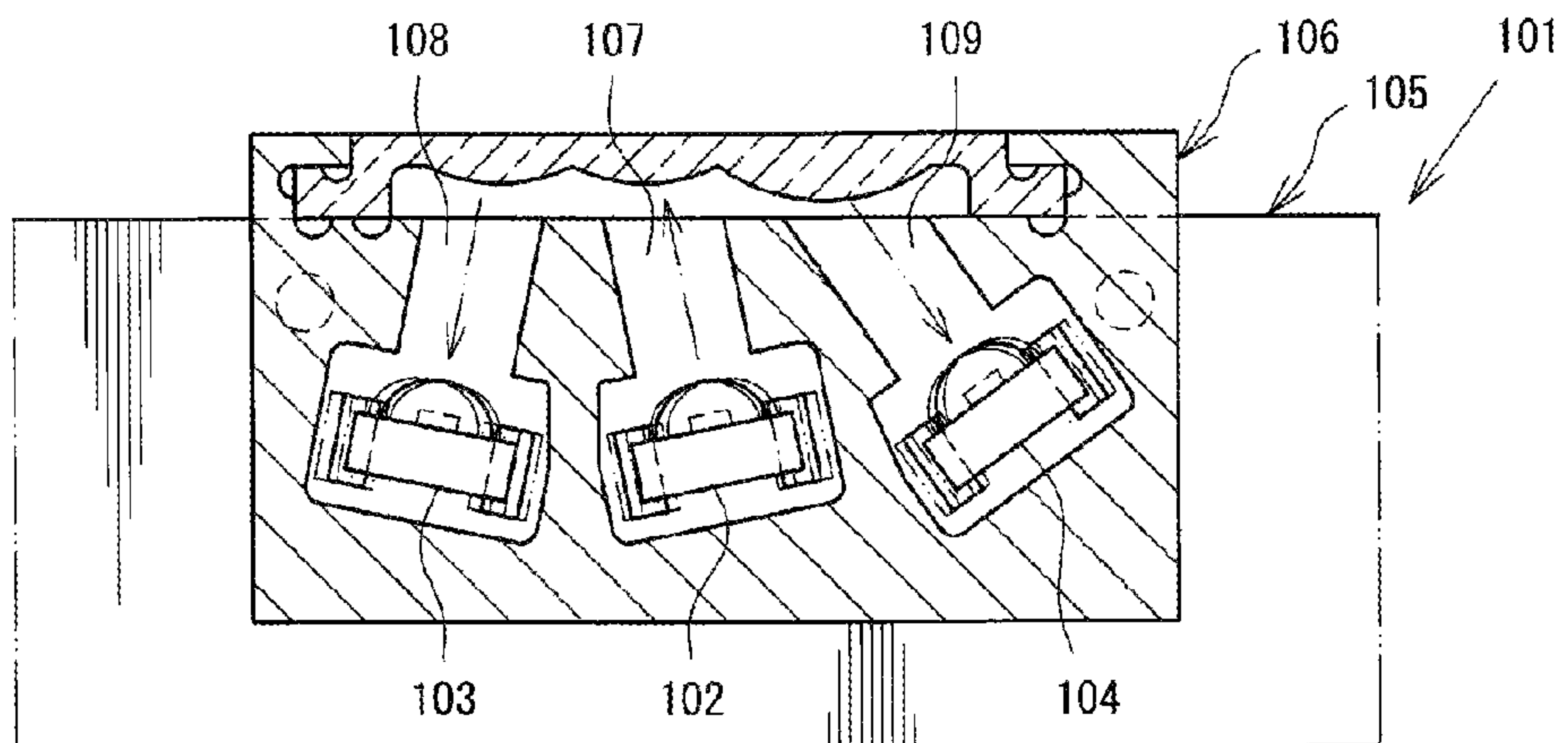


FIG. 9A

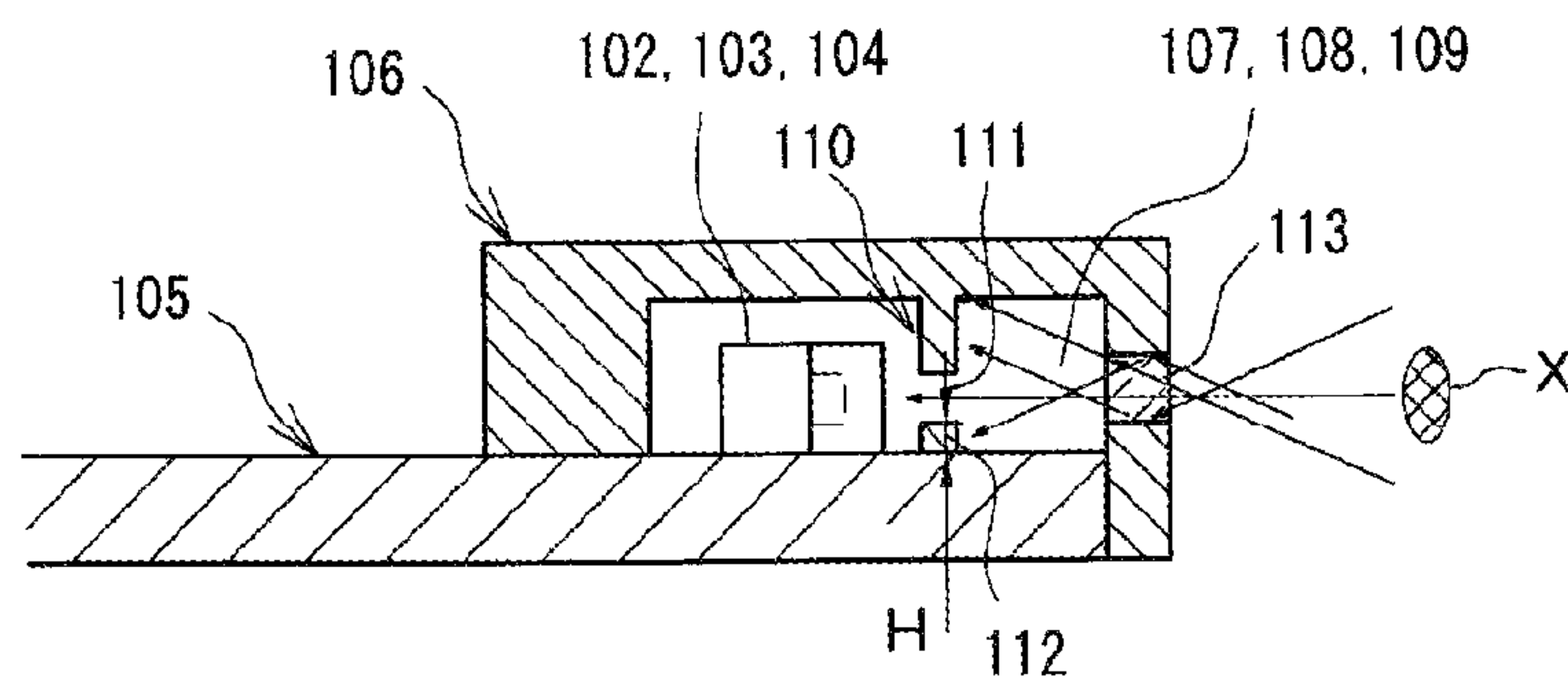
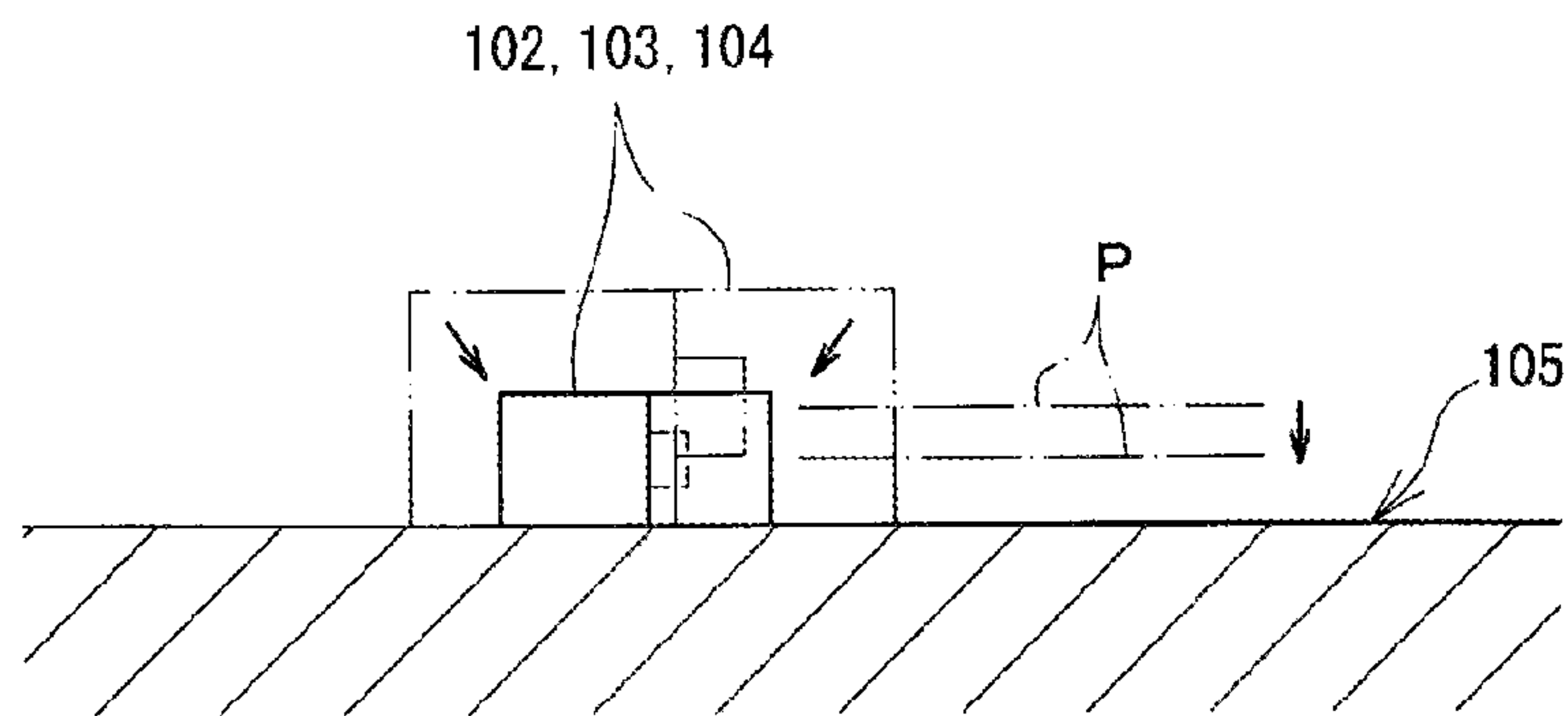


FIG. 9B





## TONER DENSITY SENSOR AND IMAGE FORMING APPARATUS

### TECHNICAL FIELD

The present invention relates to a toner density sensor that is used for an image forming apparatus such as a copying machine, a printer, and a facsimile machine, and particularly relates to such a toner density sensor as to make a balance between suppression of variations in detection accuracy and realization of size reduction.

### RELATED ART

A toner density sensor is an important component for obtaining optimum image quality in an image forming apparatus. As shown in FIG. 8, a toner density sensor 101 includes a light emitting part 102 that applies light, light receiving parts 103, 104 that receive light having been applied from the light emitting part 102 and reflected at a detection target, and an amplification unit that amplifies detection voltages of the light receiving parts 103, 104. When an image forming apparatus mounted with the toner density sensor 101 is an intermediate transfer type apparatus where a toner image primarily transferred to an intermediate belt is secondarily transferred to a paper sheet, light reflected at the toner image on the intermediate belt is detected by the light receiving parts 103, 104. A density of toner adhering to the intermediate transfer belt is detected based on a photocurrent (detection voltage) generated in the light receiving part, 103, 104, and a necessary correction is optically or electrically performed based on the detection result.

The light emitting part and the light receiving parts of the toner density sensor 101, which act as thus described, are each made up of an element such as a phototransistor, and surface-mounted on a printed substrate 105. The elements (referring to the light emitting part 102 and the light receiving parts 103, 104 herein and below) mounted on the front surface of the substrate 105 are covered by a black case 106 that is attached to the front surface of the substrate 105. In this case 106, a light blocking wall that blocks light is formed as appropriate, thereby to form a light path having an irradiation path 107 that allows passage of light applied from the light emitting part 102 onto the front surface of the substrate 105 and light receiving paths 108, 109 that allow passage of reflected light reflected at the detection target. The light path is designed in a portion under light, and the width, length and shape of the light path portion in the case 106 is designed based on a desired irradiated range and sensed range.

However, since the elements as the light emitting part 102 and the light receiving parts 103, 104 are surface-mounted on the substrate 105 as described above, there has been a problem in that mounted positions of the elements may be displaced. That is, although the element is mounted by being placed on a solder-applied land with an automatic mounting device and then soldered, the element may move at the time of melting the applied solder. This causes displacement of the element mounted position, as indicated by virtual lines in FIG. 8.

Such displacement of the mounted position occurs irregularly in each mounting, and occurs with respect to each element even on the same substrate 105. The state of occurrence of the displacement differs in each toner density sensor 101. For this reason, variations in detection accuracy (detection characteristics) have occurred among each toner density sensor 101.

In order to suppress such variations in detection accuracy, there has been proposed formation of a light path in a diaphragm unit 110 that narrows the light path, as disclosed in FIGS. 9A and 9B of Japanese Unexamined Patent Publication

No. 2005-91252. That is, as shown in FIG. 9A, the diaphragm unit 110 is formed in the vicinity of the element in the irradiation path 107 or the light receiving path 108 or 109 extending in front of the element. In FIG. 9A, numeral 113 denotes a lens.

This diaphragm unit 110 is formed in the case 106 that is attached to the front surface of the substrate 105, and formed in a shape where an opening is partially made in a partition-like portion provided so as to block the light path. When the diaphragm unit 110 is formed such that only the portion corresponding to the center in a height direction of the element allows passage of light, as indicated by an arrow shown in FIG. 9A, the diaphragm unit 110 can mainly receive light entering from a portion X that corresponds to the center in the height direction of the element, and can block light entering from the outer side of the portion that corresponds to the center in the height direction of the element. Although the direction of the arrow in FIG. 9 shows only the light receiving side, the same applies to the light emitting side.

Since the diaphragm unit 110 stops irradiated light and received light and a position to stop the light is constant in the relation between the substrate 105 and the case 106, variations in detection accuracy can be suppressed even when the position of the element is displaced.

However, since the element as the light emitting part or the light receiving part has a size as minute in the order of several millimeters, it is difficult to manufacture the case 106 formed with a hole 111 only corresponding to the center in the height direction of the element, as shown in FIG. 9A.

Furthermore, as shown in FIG. 9B, the smaller the light emitting part 102 and the light receiving parts 103, 104 are made to perform size reduction as a big advantage in using the surface mounted type light emitting part 102 and light receiving parts 103, 104, the more the center P portion of the hole 111 to be made in the diaphragm unit 110 descends, and the closer the center P portion gets to the front surface of the substrate 105. Hence a height H of a lower-side portion 112 of the hole 111 shown in FIG. 9A decreases. For this reason, in the case of using small elements, the case 106 cannot be formed.

Further, in consideration of such conditions, when the case 106 having a shape without the lower-side portion 112 of the hole 111 in the diaphragm unit 110 is used, light incident from obliquely above on the lower-side portion 112 of the diaphragm unit 110 is reflected at the front surface of the substrate 105, and the detection accuracy thus cannot be ensured.

Moreover, in the toner density sensor described in Unexamined Japanese Patent Publication No. 2005-91252, the diaphragm unit 110 is formed only in the vicinity of the element in the irradiation path 107 or the light receiving path 108 or 109 extending in front of the element. There have thus been cases where light cannot be sufficiently blocked by the diaphragm unit 110.

### SUMMARY

Thereat, it is a main object of the present invention to make a balance between suppression of variations in detection accuracy and realization of size reduction.

In accordance with one aspect of the present invention, a toner density sensor includes: a light emitting part that emits light in order to detect a toner density; a light receiving part that receives reflected light having been applied from the light emitting part and reflected at a detection target; a light path formed along the front surface of a substrate on which the light emitting part and the light receiving part are surface-mounted, the light path having an irradiation path that allows passage of light applied from the light emitting part, and a light receiving path that allows passage of the reflected light; and a diaphragm unit that is formed at the light path and



3

partially narrows the light path, wherein an upper case that covers the light emitting part and the light receiving part and forms a diaphragm unit upper portion that is one of upper and lower portions of the diaphragm unit, is provided on the front surface of the substrate, a lower case that is coupled with the upper case to hold the substrate therebetween is provided on the rear surface of the substrate, a protrusion part with its top end provided with a diaphragm unit lower portion that is one of upper and lower portions of the diaphragm unit, is formed in the lower case, and a through hole is formed in the substrate, the hole allowing the lower-side diaphragm to protrude from the front surface of the substrate and penetrating in a thickness direction of the substrate.

In this configuration, light applied from the light emitting part passes through the irradiation path, to be reflected at the detection target, and then passes through the light receiving path, to be received at the light receiving part. In traveling of this light, when the diaphragm unit is formed at the irradiation path, the diaphragm unit narrows light applied from the light emitting part to a desired irradiated range and suppress irradiation of a range other than the desired range with light regardless of a position of the light emitting part. On the other hand, when a diaphragm unit is formed at the light receiving path, the diaphragm unit allows the light receiving part to receive light in a predetermined detected range in the reflected light, and suppresses entering of light from a range other than the desired range. In such a manner, the diaphragm unit suppresses variations in detection accuracy.

This diaphragm unit is separated into two portions, and also disposed on the upper case provided on the front surface of the substrate and on the lower case provided on the rear surface of the substrate. That is, the diaphragm unit lower portion constituting the lower side portion of the diaphragm unit is arranged in the lower case provided on the rear surface of the substrate, and protrudes from the rear surface to the front surface of the substrate through the through hole, and molding is thus possible even when a required amount of protrusion from the front surface of the substrate is extremely small.

In accordance with another aspect of the present invention, there is provided an image forming apparatus mounted with the toner density sensor.

According to the present invention, with the configuration as described above where the diaphragm unit lower portion constituting the lower-side portion of the useful diaphragm unit is provided in the lower case and protruded from the rear surface to the front surface of the substrate, it is possible to mold the diaphragm unit lower portion even when a required amount of protrusion from the front surface of the substrate is extremely small. For this reason, even when the light emitting part and the light receiving part are reduced in size and a center position of the diaphragm unit gets closer to the front surface of the substrate, it is possible to reliably obtain the diaphragm unit that narrow the light path.

It is therefore possible to suppress variations in detection accuracy due to provision of the diaphragm unit, and further to realize size reduction of the toner density sensor by means of size reduction of the light emitting part and the light receiving part.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a toner density sensor;  
 FIG. 2 is a front view schematically explaining the toner density sensor;  
 FIG. 3 is a schematic configuration diagram of an image forming apparatus;  
 FIGS. 4A to 4D are a transverse sectional view and longitudinal sectional views showing a structure of the toner density sensor;

4

FIG. 5 is an explanatory view of an acting state of the toner density sensor;

FIGS. 6A to 6D are longitudinal sectional views of a toner density sensor according to another example;

FIG. 7 is a longitudinal sectional view of a toner density sensor according to another example;

FIG. 8 is a transverse sectional view of a conventional toner density sensor; and

FIGS. 9A and 9B are a longitudinal sectional view and an explanatory view showing a problematic point of the conventional toner density sensor.

#### DETAILED DESCRIPTION

Hereinafter, preferred embodiments of the present invention will be described with reference to the drawings.

FIG. 1 is a perspective view of a toner density sensor 11, and FIG. 2 is a front view schematically explaining the toner density sensor 11.

The toner density sensor 11 is mounted in an image forming apparatus 51 as shown in FIG. 3. The image forming apparatus 51 is, for example, a color laser printer or the like.

First, a schematic structure of the image forming apparatus 51 will be described as follows.

The image forming apparatus 51 is configured such that an original reading unit 52 is provided in an upper portion, an image is formed in an image forming unit 53 based on original data read with the original reading unit 52, the image is transferred to a paper sheet 54a fed from a sheet feeding unit 54 arranged at lower part, and the paper sheet is discharged from the sheet discharge unit 55 at upper part.

The image formation in the image forming unit 53 is performed by primarily transferring toner to a tensioned transfer belt 56. That is, in the image forming unit 53, light is exposed from a light writing device 57 to the photosensitive drum 58, to which toner is made to adhere, and this toner having adhered to the photosensitive drum 58 is primarily transferred to the transfer belt 56. When the paper sheet 54a is fed onto the transfer belt 56 formed with the image as described above, the image is secondarily transferred from the transfer belt 56 to the paper sheet. The paper sheet 54a after being subjected to secondary transfer is conveyed to a fixing unit 59. The fixing unit 59 fixes the toner to the paper sheet 54a by heat and pressure.

In the figure, numeral 60 denotes a charging roller, numeral 61 denotes a development sleeve, and numeral 62 denotes a toner case. In the image forming unit 63 provided with the above units and a photosensitive drum 58, four image forming units (yellow 63Y, magenta 63M, cyan 63C, black 63B) are provided, and these are sequentially disposed along the transfer belt 56.

The toner density sensor 11 is provided as opposed to the transfer belt 56 in the image forming apparatus 51, and detects a toner density on the transfer belt 56. The toner density sensor 11 may be provided in the image forming unit 63. In this case, the toner density sensor 11 detects a toner density on the photosensitive drum.

Next, the toner density sensor 11 will be described.

As shown in FIG. 2, the toner density sensor 11 has a light emitting element 12 as a light emitting part that emits light, light receiving elements 13 and 14 as light receiving part that receives reflected light having been applied from the light emitting element 12 and reflected at the transfer belt 56 as a detection target, and an amplification circuit (not shown) that amplifies detection voltages of the light receiving elements 13, 14. For example, a light emitting diode is used as the light emitting element 12, and a phototransistor, a photodiode or the like is used as the light receiving elements 13 and 14.



## 5

Any of these light emitting element **12** and light receiving elements **13**, **14** is a so-called side-view type element, which is surface-mounted in a side-edge portion of a printed substrate **15**.

Specifically, as shown by a broken line of FIG. **2**, the one light emitting element **12** and the two light receiving elements **13**, **14** are disposed substantially straight in the side-edge portion of a printed substrate **15** along the longitudinal direction thereof. As indicated by virtual lines, the one (located on the left side in FIG. **2**) of the two light receiving elements **13**, **14** is the first light receiving element **13** that receives regularly reflected light in the reflected light having been applied from the light emitting element **12** and reflected, and it mainly detects a density of black toner. The other (located on the right side in FIG. **2**) of the two light receiving elements **13**, **14** is the second light receiving element **14** that receives diffusely reflected light in the reflected light having been applied from the light emitting element **12** and reflected, and it mainly detects densities of yellow, magenta and cyan color toner.

A portion mounted with the light emitting element **12** and the light receiving elements **13**, **14** is covered by a black case **16** having light blocking properties. This case **16** is a synthetic resin molded article, and as shown in FIGS. **1** and **4A** to **4D**, the case **16** has an upper case **17** that covers the front surface of the printed substrate **15** as a side where the light emitting element **12** and the light receiving elements **13**, **14** are mounted, and a lower case **18** that covers the rear surface of the printed substrate **15**, and also holds a lens member **19** in a portion opposed to the end of the printed substrate **15**. By fitting the upper case **17** with the lower case **18** so as to hold a predetermined position of the printed substrate **15** therebetween, a fit unit (not shown) is provided in which the cases are fitted with each other.

On the front surface of the printed substrate **15** covered by the case **16**, there are provided light paths along the front surface of the printed substrate **15**, the light paths having an irradiation path **21** that allows passage of light applied from the light emitting element **12** and light receiving paths **22**, **23** that allow passage of the reflected light. The irradiation path **21** and the light receiving paths **22**, **23** have diaphragm units **25**, **26** that partially narrow the light path. These diaphragm units **25**, **26** have light blocking properties as do the inner wall surfaces of the irradiation path **21** and the light receiving paths **22**, **23**, and the positions and sizes thereof are set such that an irradiated range in a desired direction is irradiated with light or reflected light is introduced from a detected range in a desired direction.

It is to be noted that the light path is a portion under light, and a portion other than the irradiation path **21** and the light receiving paths **22**, **23** also constitutes part of the light path.

Further, although the diaphragm units **25**, **26** are formed at all of the irradiation path **21** and the light receiving paths **22**, **23** in the illustrative example, for example, they may be formed at the irradiation path **21** and the light receiving path **23** having the second light receiving element **14**, or at only any one of the irradiation path **21** and the light receiving paths **22**, **23**.

In order to suppress variations in detection accuracy in a better manner, this toner density sensor **11** has adopted a configuration where a plurality of diaphragm units **25**, **26** are formed with an interval therebetween along the longitudinal direction of the irradiation path **21** and the light receiving paths **22**, **23**, and the diaphragm unit **26** closest to the light emitting element **12** and the light receiving element **13** and **14** respectively are formed in the vicinity of the light emitting element **12** or the light receiving element **13** or **14**.

## 6

The toner density sensor **11** shown in FIGS. **2** and **4A** to **4D** has the diaphragm units **25**, **26** that narrow the light path at both ends of the irradiation path **21** or the light receiving path **22** or **23** which extends from a portion corresponding to the end of the printed substrate **15** to a housing space **27** that houses the light emitting element **12** or the light receiving element **13** or **14**. These diaphragm units **25**, **26** are each made up of a partition-like wall unit **28** protruding toward the inner side so as to block the light path, and a hollow **29** surrounded by this wall unit **28**. The thickness of the wall unit **28** and the position and the size of the hole **29** are designed such that the desired irradiated range is irradiated with light, or reflected light is introduced from the desired detected range, as described above. The holes **29** of the two diaphragm units **25**, **26**, arrayed in the longitudinal direction of each of the light emitting element **12** and the light receiving elements **13**, **14** have the same sizes. They can be made different sizes as required.

In the diaphragm units **25**, **26** of the irradiation path **21**, the diaphragm unit **26** in the vicinity of the light emitting element **12** is one to first block an unnecessary portion of irradiated light applied from the light emitting element **12**, and the diaphragm unit **25** located at the end of the printed substrate **15** is one to block an unnecessary portion of the irradiated light which could not be blocked by the diaphragm unit **26** in the vicinity of the light emitting element **12**.

In the diaphragm units **25**, **26** of the light receiving paths **22**, **23**, the diaphragm unit **25** located at the end of the printed substrate **15** is one to first block an unnecessary portion of reflected light, and the diaphragm unit **26** in the vicinity of the light receiving element **13** or **14** is one to block an unnecessary portion of the reflected light which could not be blocked by the diaphragm unit **25** located at the end of the printed substrate **15**.

Further, in order to achieve the object of suppressing variations in detection accuracy and also dealing with size reduction, as shown in FIG. **4B**, the toner density sensor **11** has adopted a configuration such that, as shown in FIG. **4B**, diaphragm unit upper portions **25a**, **26a**, obtained by vertically separating the diaphragm units **25**, **26** into two portions, are provided in the upper case **17**, protrusions **30** formed at the upper end thereof with diaphragm unit lower portions **25b**, **26b**, obtained by vertically separating the diaphragm units into two portions, are provided in the lower case **18**, and through holes **31** are formed in the substrate **15**, the holes allowing the diaphragm unit lower portions **25b**, **26b** to protrude from the front surface of the substrate **15** and penetrating the substrate in the thickness direction.

FIG. **4B** is a sectional view showing a schematic structure in a state vertically cut at the center in the longitudinal direction of the irradiation path **21** or the light receiving path **22** or **23**. FIG. **4C** is an A-A sectional view of FIG. **4B**, and FIG. **4D** is a B-B sectional view of FIG. **4B**.

As shown in these figures, on the inner surface of the upper case **17**, other than the housing space **27** and the irradiation path **21** or the light receiving path **22** or **23**, the diaphragm unit upper portions **25a**, **26a** as parts of the diaphragm units **25**, **26** are formed. The diaphragm unit upper portions **25a**, **26a** have shapes of the upper side portions at the time of vertical division of the wall unit **28** with the center of the hole **29** as a boundary, and suspended from the ceiling surface of the irradiation path **21** or the light receiving path **22** or **23**.

Meanwhile, the diaphragm unit lower portions **25b**, **26b** as parts of the diaphragm units **25**, **26** are formed in the lower case **18**. The diaphragm unit lower portions **25b**, **26b** have shapes of the lower side portions at the time of vertical division of the wall unit **28** with the center of the hole **29** as the



boundary, and the upper edges of the diaphragm unit lower portions **25b**, **26b** are formed so as to abut on the lower edges of the diaphragm unit upper portions **25a**, **26a**.

Since the diaphragm unit lower portions **25b**, **26b** are ones to protrude from the rear surface to the front surface of the printed substrate **15** as described above, the diaphragm unit lower portions **25b**, **26b** are integrally provided at the upper ends of the protrusions **30** that have heights as large as the thickness of the printed substrate **15**. The protrusions **30** are erected in portions of the upper surface of the lower case **18** which correspond to the diaphragm unit upper portions **25a**, **26a** of the upper case **17**.

The through holes **31** to be fitted with and correspond to the lower protrusions **30** under the diaphragm unit lower portions **25b**, **26b** are formed in portions of the printed substrate **15** which correspond to the diaphragm unit lower portions **25b**, **26b**. The through hole **31** to be fitted with the protrusion **30** supporting the diaphragm unit lower portion **25b** located at the end of the printed substrate **15** has a notched shape where a portion corresponding to the end of the printed substrate **15** is opened, and the through hole **31** to be fitted with the protrusion **30** supporting the diaphragm unit lower portion **26b** in the vicinity of the light emitting element **12** or the light receiving element **13** or **14** has a hole-like shape with its periphery closed.

In the toner density sensor as thus configured, light from the light emitting element **12** passes through the irradiation path **21** and applied toward the transfer belt **56**, and as shown in FIG. 4A, reflected light reflected at the transfer belt **56** passes through two light receiving paths **22**, **23** and is received at the respective light receiving elements **13**, **14**. When light passes through the irradiation path **21** or the light receiving paths **22**, **23**, the diaphragm units **25**, **26** regulate the range of applied light, or regulate the detected range of received light.

That is, when it is described by taking the time of receiving light as an example, as indicated by an arrow in FIG. 5, reflected light from a detected range A to the diaphragm units **25**, **26** enters straight toward the light receiving elements **13**, **14**, to be detected at the light receiving elements **13**, **14**. On the other hand, reflected light in a range out of the detected range A is blocked by the first diaphragm unit **25**, namely the diaphragm unit **25** at the end of the printed substrate **15**. Further, reflected light in a range out of the detected range A in the reflected light having passed through the first diaphragm unit **25** is reflected inside the light receiving paths **22**, **23** and blocked by the back diaphragm unit **26**.

The diaphragm units **25**, **26** in the irradiation path **21** act in a similar manner, and perform regulation so as not to apply light to a range out of an irradiated range B.

As described above, since the irradiated range B with light and the detected range A of received light are appropriately adjusted by the diaphragm units **25**, **26** in the case **16** fixed to the printed substrate **15**, even when mounted positions of the light emitting element **12** and the light receiving elements **13**, **14** are displaced from predetermined positions, it is possible to suppress variations in irradiated range B and detected range A regardless of the displacement. For this reason, it is possible to obtain uniform detection accuracy which is not affected by the mounted positions of the light emitting element **12** and the light receiving elements **13**, **14**.

Furthermore, with the plurality of diaphragm units **25**, **26** provided, the effect of blocking excess light by the diaphragm units **25**, **26** is sufficiently obtained as compared with the conventional toner density sensor (toner density sensor described in Unexamined Japanese Patent Publication No. 2005-91252) provided with the diaphragm units **25**, **26** only

in the vicinity of the element, so as to more favorably eliminate variations in detection accuracy.

Moreover, despite the fact that the diaphragm units **25**, **26** that achieve the effect as thus described are formed on the front surface side of the printed substrate **15**, the units are configured by going to all the trouble to make part thereof shared by the lower case **18** provided on the rear surface of the printed substrate **15**. With such a configuration, no matter how smaller a height H of the diaphragm unit lower portions **25b**, **26b** as the lower-side portion is than the hole **29** of the diaphragm units **25**, **26**, the diaphragm unit lower portions **25b**, **26b** can be molded to exist on the front surface of the printed substrate **15**.

For this reason, even when size reduction in light emitting element **12** and light receiving elements **13**, **14** is performed, and the positions to be formed with the diaphragm units **25**, **26** become closer to the front surface of the printed substrate **15**, it is possible to reliably obtain such diaphragm units **25**, **26**. That is, as described above, it is possible to realize size reduction while favorably suppressing variations in detection accuracy.

Furthermore, the diaphragm unit lower portions **25b**, **26b** are provided in a state where the protrusions **30** integrally provided with the diaphragm unit lower portions **25b**, **26b** are penetrated through the printed substrate **15**, thereby forming a firm structure free from damage by vibrations and the like.

Hereinafter, the other examples will be described. In this description, the same or similar portion as or to the foregoing configuration will be provided with the same numeral, and its detailed description will be omitted.

FIG. 6A shows an example where the diaphragm unit **25** is continuously formed along the longitudinal direction of the irradiation path **21** and the light receiving paths **22**, **23**, and the end of the diaphragm unit **25** on the light emitting element **12** or the light receiving element **13** or **14** side is formed in the vicinity of the light emitting element **12** or the light receiving element **13** or **14**. In this example, the diaphragm unit **25** is formed over the longitudinal direction of the light receiving paths **22**, **23** and the irradiation path **21** from a position corresponding to the end of the printed substrate **15** to the housing space **27**.

In the toner density sensor **11** as thus configured, reflected light that enters from the outside of the detected range A is reflected at the inner surface of the diaphragm unit **25** of the light receiving paths **22**, **23**, but attenuates due to repeated reflection, and hence it is possible to prevent such reflected light from affecting detection performed by the light receiving elements **13**, **14**. Since a higher effect can be obtained by a larger number of times of reflection, the diaphragm unit **25** is desirably formed long.

Even with the irradiation path **21**, a similar action as above can be obtained.

FIG. 6B shows an example where the diaphragm unit lower portions **25b**, **26b** of the diaphragm units **25**, **26** formed at both ends of each of the light receiving paths **22**, **23** and the irradiation path **21** in the longitudinal direction, as shown in FIG. 4B, are integrally formed. That is, the protrusion **30** formed in the lower case **18** is formed to have the same length as those of the light receiving paths **22**, **23** and the irradiation path **21**, and the diaphragm unit lower portions **25b**, **26b** are integrally provided at both ends of the upper end of the protrusion.

The toner density sensor **11** as thus configured has such an advantage as to be easy to manufacture since the protrusion **30** can be formed to be large even when size reduction is performed.



FIGS. 6C and 6D show examples of a combination of plural formation with an interval therebetween along the longitudinal direction of the irradiation path **21** and the light receiving paths **22**, **23** and continuous formation in the longitudinal direction. That is, the diaphragm unit **25** shown in FIG. 6C is an example where the diaphragm unit upper portion **25a** is formed in a continuous shape over the longitudinal direction of the irradiation path **21** or the light receiving path **22** or **23**, and the diaphragm unit lower portions **25b**, **25c** are formed at both ends in the longitudinal direction of the irradiation path **21** or the light receiving path **22** or **23**. FIG. 6D shows an example where the diaphragm unit **25** of FIG. 6C is configured upside down. In FIG. 6D, numeral **25d** denotes a diaphragm unit upper portion.

Also in the toner density sensor **11** as thus configured, similarly to the above, it is possible to regulate the detected range A and the irradiated range B.

FIG. 7 shows an example where, in the diaphragm unit upper portion **26a** and the diaphragm unit lower portion **26b** that constitute the diaphragm unit **26**, a fit structure is formed in which these units are fitted with each other. A similar configuration thereto can be formed in both the case where a plurality of diaphragm units **26** are provided as shown in FIG. 4 and the like and the case where a single diaphragm unit **26** is provided as shown in FIG. 6A.

FIG. 7 is a longitudinal sectional view of the diaphragm unit **26** portion, and as shown in this figure, fit holes **32** for fitting are formed in the upper surface of the diaphragm unit lower portion **26b**, while fit protrusions **33** to be fitted into the fit holes **32** are formed in the lower surface of the diaphragm unit upper portion **26a**.

In the toner density sensor **11** as thus configured, the fit holes **32** and the fit protrusions **33** are fitted with each other also in the diaphragm unit **26**. Accordingly, even in the case of the diaphragm unit **26** with a vertically divided structure, the diaphragm unit **26** having a desired shape can be obtained. Furthermore, since holding the fit state allows the upper case **17** and the lower case **18** to be held in the fixed state to the printed substrate **15**, when the fit holes **32** and the fit protrusions **33** are ones having individual fit strength, the other structure for holding the fit state of the upper case **17** and the lower case **18** can be omitted or simplified.

In a correspondence between the configuration of the present invention and the configuration of the foregoing one embodiment,

the light emitting part of the present invention corresponds to the light emitting element **12**;

and similarly to this,

light receiving part corresponds to the light receiving elements **13**, **14**;

the detection target corresponds to the transfer belt **56**;

the substrate corresponds to the printed substrate **15**; and

the fit structure corresponds to the fit hole **32** and the fit protrusion **33**.

However, the present invention is not restricted to the foregoing configuration, and another configuration can also be adopted.

For example, the shape of the diaphragm unit upper portion and the diaphragm unit lower portion is not restricted to the shape vertically divided with the central position of the hole unit as the boundary, but it may be a vertically intricate shape.

What is claimed is:

1. A toner density sensor, comprising:

a light emitting part that emits light in order to detect a toner density;

a light receiving part that receives reflected light having been applied from the light emitting part and reflected at a detection target;

a light path formed along the front surface of a substrate on which the light emitting part and the light receiving part are surface-mounted, the light path having an irradiation path that allows passage of light emitted from the light emitting part and a light receiving path that allows passage of the reflected light; and

a diaphragm unit that is formed at the light path and partially narrows the light path, wherein

an upper case that covers the light emitting part and the light receiving part, and forms the light path and a diaphragm unit upper portion, is provided on the front surface of the substrate, the diaphragm unit upper portion being one of upper and lower portions of the diaphragm unit,

a lower case that is coupled with the upper case to hold the substrate therebetween is provided on the rear surface of the substrate,

a protrusion part with its top end provided with a diaphragm unit lower portion is formed in the lower case, the diaphragm unit lower portion being one of upper and lower portions of the diaphragm unit, and

a through hole is formed in the substrate, the hole allowing the diaphragm unit lower portion to protrude from the front surface of the substrate and penetrating in a thickness direction of the substrate.

2. The toner density sensor according to claim 1, wherein a plurality of diaphragm units are formed with an interval therebetween along a longitudinal direction of at least one of the irradiation path and the light receiving path, and

the diaphragm units closest to the light emitting part and the light receiving part respectively are formed in the vicinity of the light emitting part or the light receiving part.

3. An image forming apparatus on which the toner density sensor according to claim 2 is mounted.

4. The toner density sensor according to claim 2, wherein in the diaphragm unit upper portion and the diaphragm unit lower portion, a fit structure is formed in which the diaphragm unit upper portion and the diaphragm unit lower portion are fitted with each other.

5. An image forming apparatus on which the toner density sensor according to claim 4 is mounted.

6. The toner density sensor according to claim 1, wherein the diaphragm unit is continuously formed along a longitudinal direction of at least one of the irradiation path and the light receiving path, and

an end of the diaphragm unit on the light emitting part or the light receiving part side is formed in the vicinity of the light emitting part or the light receiving part.

7. An image forming apparatus on which the toner density sensor according to claim 6 is mounted.

8. The toner density sensor according to claim 6, wherein in the diaphragm unit upper portion and the diaphragm unit lower portion, a fit structure is formed in which the diaphragm unit upper portion and the diaphragm unit lower portion are fitted with each other.

9. An image forming apparatus on which the toner density sensor according to claim 8 is mounted.

10. The toner density sensor according to claim 1, wherein in the diaphragm unit upper portion and the diaphragm unit lower portion, a fit structure is formed in

**11**

which the diaphragm unit upper portion and the diaphragm unit lower portion are fitted with each other.

**11.** An image forming apparatus on which the toner density sensor according to claim **10** is mounted.

**12.** An image forming apparatus on which the toner density sensor according to claim **1** is mounted.

\* \* \* \* \*

**12**